## ABSTRACT

**Title: Layered Materials as High Temperature Membranes in Hydrogen Production)**

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## OBJECTIVES

IGCC plants show promise for environmentally-benign power generation. In these plants coal is gasified to synthesis gas, which is then processed in a water gas-shift reactor (WGSR) to produce $H_2$ for clean-power generation. WGSR is a dual-reactor system, the first reactor (HTS) operating at high temperatures, to attain high reaction rates, followed by a second lower-temperature reactor (LTS), which benefits from increased equilibrium conversions at low temperatures. The WGSR exit stream contains $H_2$, $CO_2$, $H_2O$ and other minor species (e.g., CO). For use in fuel cells (and potentially for $CO_2$ capture/sequestration), $CO_2$ is separated using amine absorption or PSA. Both processes are, however, energy- and capital-intensive, and so is the WGSR. In their place our team proposes, instead, a novel membrane reactor (WGSMR), which integrates the WGS and $CO_2$ separation steps in a single unit through the use of high temperature, $CO_2$-selective membranes. The WGSMR has many advantages over the conventional technology. Key to the success of the WGSMR is developing $CO_2$-selective membranes, capable of operating in the WGS environment, since commercial membranes are not functional in this environment. The objective of this project is, therefore, the development of a new high temperature, affinity-type $CO_2$-selective membrane.

## ACCOMPLISHMENTS TO DATE

We have utilized a variety of methods to prepare affinity-type $CO_2$-selective membranes. We have used a number of hydrotalcite (HT) sources and supports. We have also prepared two types of membranes, large area membrane disks and tubes, and micromembranes prepared on stainless steel foils and silicon wafers. The micromembranes show good potential for application in micro-fuel cells. The membranes have been tested for their transport characteristics using both single gases and mixtures of gases, as well as by a variety of other characterization techniques including SEM and

TEM, DRIFTS, EDX, and DTA/TGA. Quality nanoporous membranes have been prepared, which show significantly higher permeation rates for gases with smaller kinetic diameters like He (used here as a safe surrogate gas for hydrogen) as compared to gases with larger kinetic diameters like Ar. Some of these membranes are selective towards $CO_2$. The effect of preparation conditions on the membrane transport characteristics have also been studied and will be reported at the meeting.

## FUTURE WORK

The following work is planned for the remainder of this project:

- We plan to continue the preparation of the HT membranes and their characterization using single gases and gas mixtures relevant to the WGS environment. In particular, the hydrothermal stability of these membranes will be tested in the synthetic WGS environment

- In parallel with the membrane preparation and characterization experiments, we will initiate research to understand the potential of these membranes in the WGSMR system. The combined simulation and experimental studies will provide insight into how the existing membranes work, and guidance in the development of $2^{nd}$ generation membranes.

## LIST OF PAPER PUBLISHED

A paper is in preparation, and will be submitted to Industrial Engineering Chemistry Research. Results of this research will also be presented at the upcoming AIChE Annual Meeting in San Francisco.

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